Population Structure and Tree Health of Flowering Dogwood at Gettysburg National Military Park after 15 Years of Infestation by Dogwood Anthracnose

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This is a cooperative project between the United States Forest Service, Forest Health Protection and Gettysburg National Military Park (GNMP). The purpose of this project is to assess the survival and health of flowering dogwood (*Cornus florida*), an important ornamental and wildlife tree in Eastern North America. This project is a continuation of a similar survey conducted in 1989 and has revealed a decrease in the population of flowering dogwoods presumably due to the dogwood anthracnose (Causal agent: *Discula destructiva*). This survey was conducted to assess the current population levels of this species via comparisons from results of prior studies conducted at GNMP.

Background and Introduction:

The flowering dogwood is highly regarded for both its ornamental value and importance as a wildlife tree. The showy springtime display of its petal-like white bracts has made it one of America's most renowned tree species. The clustered, bright red fruit of dogwood, while unsuitable for human consumption, support a wide variety of bird species as well as a large variety of mammals (Halls, 1977). Dogwood tends to be a short shrub (30 to 40 feet tall) with an upper diameter limit of about sixteen inches (Vimmerstedt, 1965). The native range of dogwood extends from extreme southeastern Canada and Maine south to Florida and as far west as Kansas and Texas (Vimmerstedt, 1965). However, over the last thirty years the population of dogwoods has seriously declined presumably due to dogwood anthracnose, caused by *Discula destructive*.

Dogwood anthracnose is thought to be an exotic disease first reported in North America in 1979, although the origins of the fungus are still unknown (Trigiano et al., 1995). The relative resistance exhibited in the Asian dogwood (*Cornus kousa*) suggests that the disease may have originated in Asia. Recent molecular work has suggested a single, recent introduction in to North America (Trigiano et al., 1995). However, the apparent decrease in disease virulence over the last two decades suggests an increase in genetic diversity of *D. destructiva* fungal populations among North American populations (Zhang and Blackwell, 2002). Two species of the genus *Cornus* are susceptible to anthracnose, *C. florida* and *C. nuttallii* (Salogga and Ammirati, 1983). The spread of this pathogen threatens eastern flowering dogwoods across most of its native range, from as far north as Maine, throughout the Appalachians, south to Georgia and as far east as Illinois (Daughtrey, 1994). Spores of *D. destructive* are spread mostly by rain splash (Daughtrey, 1994). However, humans and other animals may disseminate infected fruit and seeds (Britton, 1993). Almost all portions of the tree appear susceptible to disease as *D. destructiva* has been isolated from leaves, flowers, stems, fruits and seeds of infected dogwood trees (Britton and Roncadori, 1993).

Anthracnose severity appears to be affected by humidity, temperature and light conditions (Daughtrey, 1994). Free moisture, in the form of dew or rain is necessary for infection. Disease incidence is often higher during years with higher than average rainfall (Britton, 1993). Secondary cycles of leaf infection may occur during periods of heavy rains (Daughtrey, 1994). There is an inverse correlation between leaf exposure to sunlight and disease severity, with infection greater in shaded understory trees, in the interior and on the north side of canopies, trees at lower elevations, and in trees with north to east aspects (Daughtrey, 1994). Disease pressure has limited populations of dogwoods to the edges of forest stands, where sunlight, temperature and moisture factors support dogwood growth and inhibit disease infection.

While rainfall is conducive to disease infection, it also promotes host vigor and thereby lessens disease impact (Gould, 1994). Trees stressed by drought or winter injury are more susceptible to disease infection.

Leaf symptoms include necrotic lesions surrounded by a reddish or brown-purple zone and necrotic blotches on the leaf tips and along the veins and leaf margins (Photo 1) (Hibben, 1988). Leaves infected early in the season usually abscise. Leaves infected late in the season may remain attached until the following spring and are a source of overwintering inoculum (Britton et al., 1993). Rainy conditions will encourage spotting on bracts (Daughtrey, 1994). Twig dieback and epicormic branching are common symptoms of infection (Daughtrey, et al., 1998). Leaf symptoms and twig dieback generally begins in the lower crown and progresses up the tree (Britton, 1993). Infections often progress down the petioles and into shoots, resulting in cankers. Annual cankers often occur on the main stem and lead to twig dieback. Multiple cankers can girdle branches or the main stem and eventually results in tree mortality.

Photo 1. Foliar symptoms of Dogwood Anthracnose (*Discula destructive)* infection. Photo credit: Danielle Martin

A similar survey was conducted at GNMP in 1989 by Jackson and Arbucci (1989). The 1989 survey estimated an average of 539 flowering dogwoods per acre with 15% mortality. While dogwood anthracnose was confirmed to be present, researchers could not verify that the pathogen was the cause of death. However, symptoms of dogwood anthracnose were found to be present on 68% of trees surveyed. An additional survey was necessary to evaluate disease progression and to assess the current population levels of this species.

Project Objectives

The purpose of this project was to determine the presence of dogwood anthracnose and to evaluate the condition of the flowering dogwoods at Gettysburg National Military Park. While survey methods were slightly modified, all data has been converted into standard measurements (trees per acre, percent of trees in each diameter class, etc.) to allow for comparisons over time.

Methods

This study was conducted at GNMP in Gettysburg, Pennsylvania (N 39° 48' 44.4954", W 77° 14' 46.5828"). GNMP is a 5,989 acre park, consisting of a variety of ecosystems, including agriculture fields, mature and maturing forested areas, pasturelands and intermittent streams (National Park Service, 2013). The forested areas comprise of a dominant overstory of white oak, white ash and northern red oak. The understory consists of a mixture of black cherry, spicebush and white ash samplings. GNMP is the site of the American Civil War Battle of Gettysburg, the Soldiers' National Cemetery and the commemoration of the great battle of Civil War Veterans (National Park Service, 2013).

In order to estimate dogwood trees per acre along roadsides at GNMP, a complete census of flowering dogwood within 8 feet of the forests edge along every major road was conducted. All live and dead flowering dogwood were counted and positions recorded using a Garmin® 60CSx GPS unit. All field measurements were made in June of 2013. Dogwoods were located from the passenger side of a slow-moving vehicle. In order to assess the health of flowering dogwoods along roadsides, a subsample of 32 individual trees were randomly chosen and assessed for disease severity, as described below.

For each tree, we recorded diameter-at-breast-height (DBH), 4.5 feet above the ground, and trees were placed into one of 5 size classes (<1", 1-1.9", 2-2.9", 3-3.9", and ≥4"). Crown symptoms based on the percentage of crown exhibiting leaf symptoms and/or dieback due to dogwood anthracnose (Class 0 = dead, Class 1 = > 75% foliage affected, Class 2 = 51-75% foliage affected, Class 3 = 26-50% foliage affected, Class 4 = 1-25% foliage affected, Class 5 = healthy) were determined for each tree. Crown symptoms based on the percentage of crown exhibiting leaf symptoms and/or dieback due to powdery mildew (none, low = 1-33% foliage affected, moderate = 34-66% affected, high = 67-100% affected) was also determined for each tree.

A trail survey was also conducted in which a census and assessment of disease severity was made within 8 feet of the trails right-side edge for every major trail in the park. The data from the road survey and trail survey were analyzed individually and also combined to give an estimate trees per acre (TPA) and health of flowering dogwood populations.

To estimate the total number of dogwood per acre data we used digitized 2008 National Agriculture Imagery Program aerial photo to estimate the total number of acres in the Park and the proportion of forested and road edge acreages were calculated. We estimated that 2,005 acres of the Park are in forested condition. For our analyses of the roadside trees, we estimated 650 acres of road conditions by multiplying the length of the road system by road width plus a 60 foot buffer on each side to account for edge effects.

Results

A total of 583 flowering dogwoods were counted along every major road within GNMP. Using an estimate of 650 acres of road area, we projected 20.9 TPA along roadsides (Table 1). Twenty eight dogwoods were found within the 3.5 miles of trails accessed. We estimated 7.3 TPA along trails (Table 2) for a combined total of 28.2 TPA. A 1989 survey estimated 539 total dogwood TPA, reflecting a 95% loss (Jackson and Arbucci, 1989).

Average dogwood tree diameter has increased since 1989. In 1989, 81% of trees were less than an inch in diameter. The 2013 survey found only 1.7% in the less than an inch category, 16.7% to be in the 1 to 2 inch category, 33% of trees to be in the 2 to 3 inch category, 23% to be in the 3 to 4 inch category and 25% to be greater than 4 inches in diameter (Figure 1).

Disease severity appears to be slowly fluctuating over time (Figure 2). No trees were found to be completely uninfected by anthracnose in 2013; however, 17% of trees were rated as being free of anthracnose in 1989. In 2013 the majority (75%) of trees were placed into dogwood anthracnose disease class 4 (1-25% affected). In 1989, the majority (30%) of dogwoods were also in disease class 4. Ten individual trees (16.7%) were dead in 2013 whereas only 15% of trees were dead in 1989.

The majority (42%) of trees exhibited a low powdery mildew disease rating (Figure 3). Thirty one percent were in the moderate category, 10% were in the high category and 17% were dead.

Size class	Count	Prop	Percent of total	TPA	Standard Error	Dieback Class GNB Road Data[a]											
						0	%	1	%	2	%	3	%	4	%	5	%
<1	1	0.0	3.0	0.6	3.2	0	0	0	0	0	0	0	0	1	100	0	0
1-2	5	0.2	15.2	3.2	16.0	0	0	0	0	0	0	1	20	4	80	0	0
2-3	7	0.2	24.2	5.1	25.6	0	0	0	0	0	0	0	0	7	100	0	0
3-4	8	0.2	24.2	5.1	25.6	2	25	0	0	0	0	0	0	6	75	0	0
>4	11	0.3	33.3	7.0	35.3	1	9	0	0	1	9	1	9	8	73	0	0
	32	1.0	100	20.9	105.8	3	9	0	0	1	3	2	6	26	81	0	0

Table 1. Flowering dogwood trees per acre by size class and dieback class along roads at Gettysburg National Military Park, 2013. [a]Percentage of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy.

Size class	Count	Prop	Percent of total	TPA	Standard Error	Dieback Class GNB Trail Data[a]											
						0	%	1	%	2	%	3	%	4	%	5	%
<1	0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	5	0.2	17.9	1.3	3.1	0	0	0	0	0	0	0	0	5	100	0	0
2-3	13	0.5	46.4	3.4	8.1	2	15	0	0	0	0	1	8	10	77	0	0
3-4	6	0.2	21.4	1.6	3.8	4	67	0	0	0	0	1	17	1	17	0	0
>4	4	0.1	14.3	1.0	2.5	1	25	0	0	0	0	0	0	3	75	0	0
	28	1.0	100	7.3	17.5	7	25	0	0	0	0	2	7	19	68	0	0

Table 2. Flowering dogwood trees per acre by size class and dieback class along trails at Gettysburg National Military Park, 2013. [a]Percentage of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy.

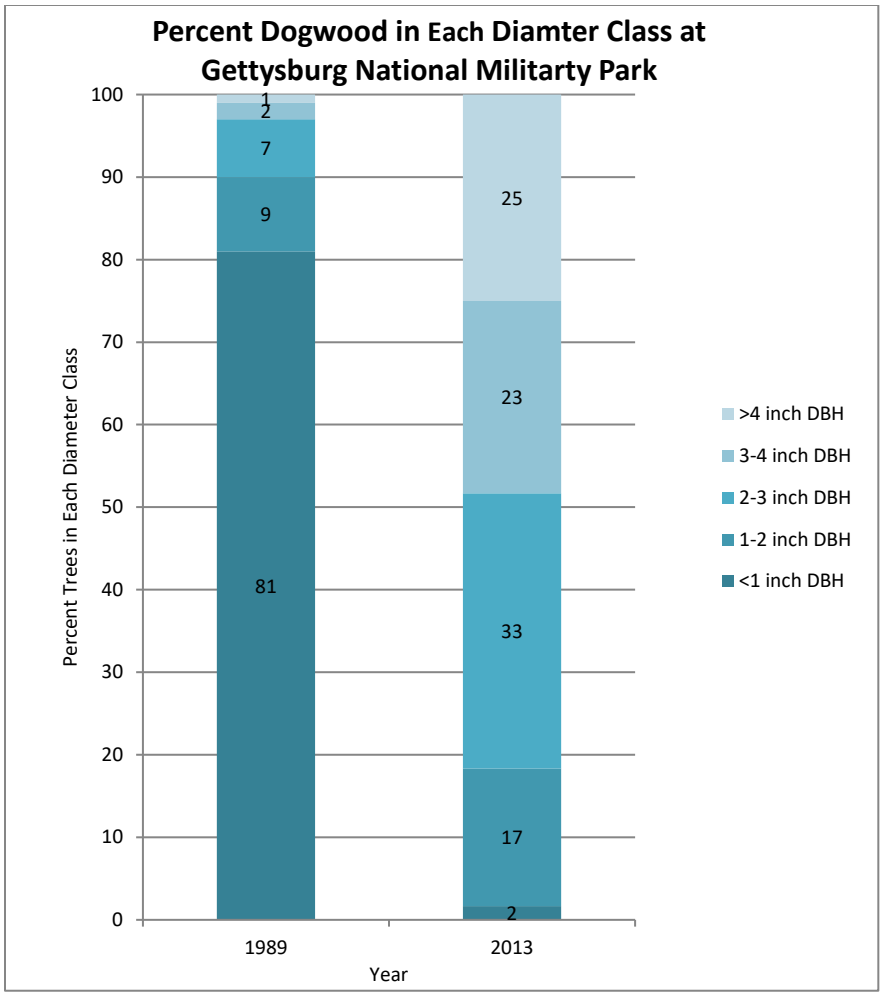

Figure 1. Percentage of flowering dogwoods in each diameter class at Gettysburg National Military Park in 1989 (Jackson and Arbucci, 1989) and 2013. Diameter data from 2013 includes combined forest and road survey data.

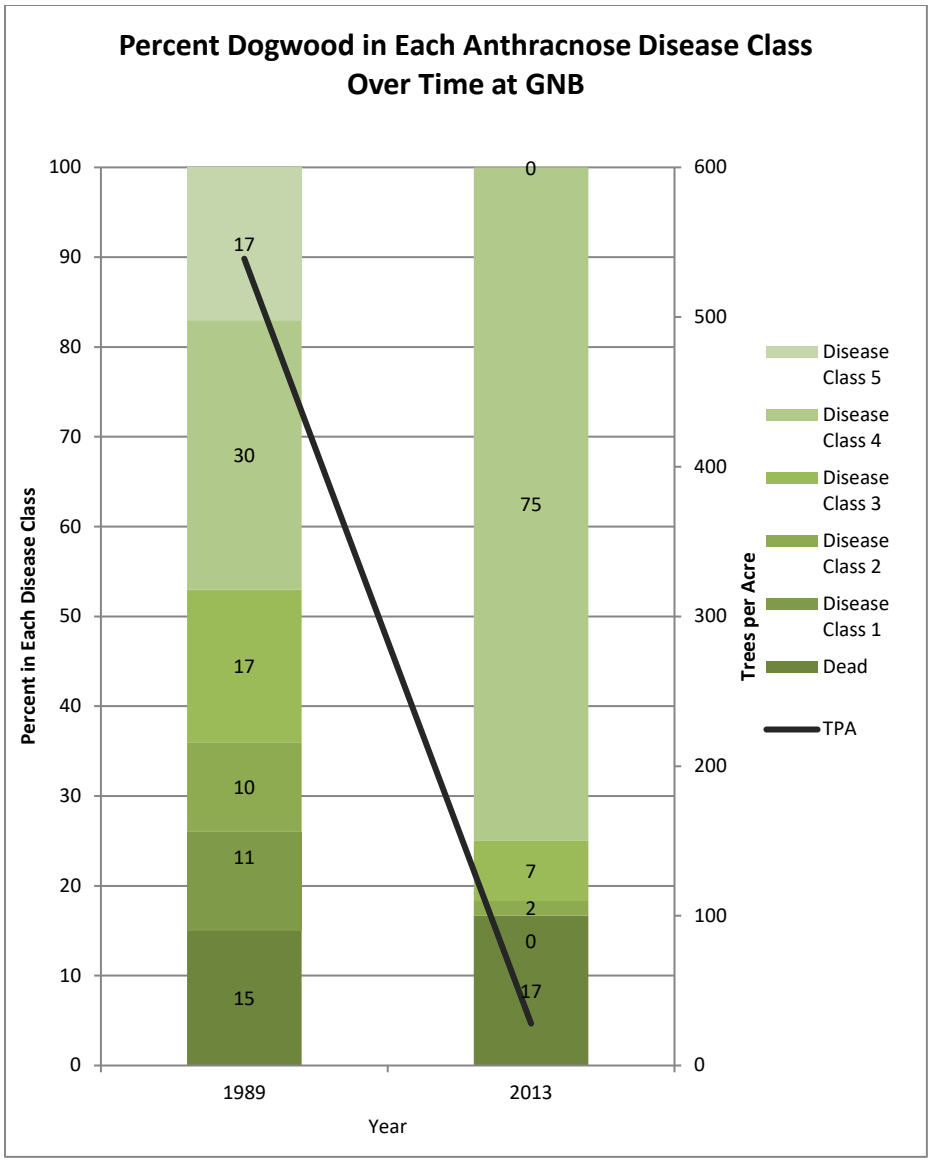

Figure 2. Percentage of flowering dogwoods in each anthracnose disease class at Gettysburg National Battlefield in 1989 (Jackson and Arbucci, 1989) and 2013. Disease class represents percentage of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy. Trees per acre (TPA) included both live and dead trees. Disease class data from 2013 includes combined forest and road survey data.

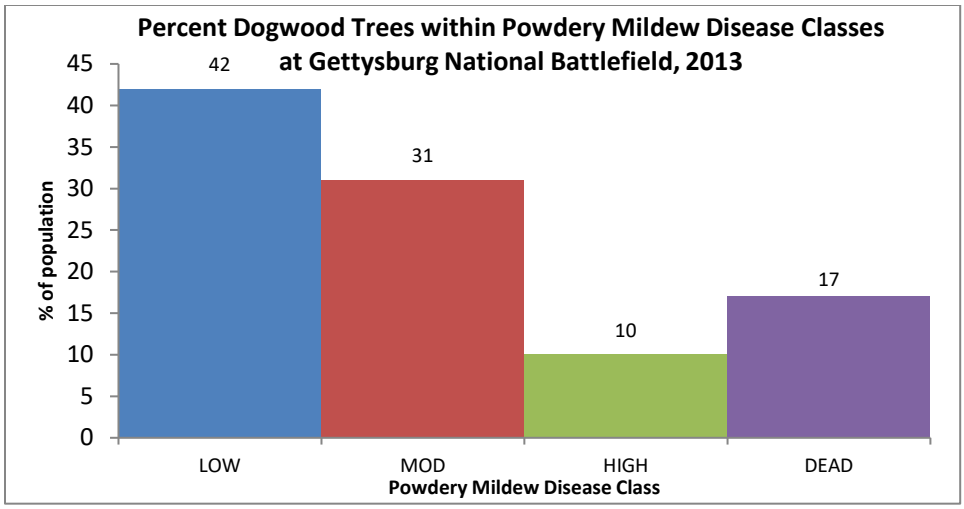

Figure 3. Estimated population of flowering dogwoods in powdery mildew disease classes at Gettysburg National Battlefield, 2013. Percentage of tree exhibiting leaf symptoms: none, low = 1-33% foliage affected, moderate = 34-66% affected, high = 67-100% infected. Disease class data includes combined forest and road survey data.

Discussion:

As of July 2013, there has been a significant reduction in the number of flowering dogwood trees per acre since the first study that was conducted in 1989 (Figures 1 and 2). Interestingly, an examination of the remaining live trees shows that health of the trees appears to be increasing (Figure 2). This was probably due to more susceptible trees dying off but could also be due to survival of trees growing in environments less suitable to disease development. Future studies should focus on tracking the health of individual trees versus areas where dogwood are regenerating as this would allow differentiation between susceptible and natural reproduction of resistant dogwood.

Management of flowering dogwood in the presence of dogwood anthracnose requires manipulation of disturbances, host resistance, and intensive husbandry of individual trees. In a forested setting, the only practical management options include host resistance (natural or planting resistant trees) and site manipulation. The relatively high moisture requirements (Britton, 1993) for disease development in combination with the anecdotal relative ease with which dogwood can be located in large clearings (e.g. along roadsides and rock cliffs, in areas of blow-down, etc.) indicates that any form of natural or artificial disturbances should maintain the species. If it were desirable to increase the proportion of dogwood allowing disturbances such as fire or any other disturbance that shifts a mature, closed-canopy to an earlier seral condition would be expected to also result in an increase in flowering dogwood. If desired, high-value trees can be treated individually to promote tree health with many different techniques singly or in combination: irrigation during drought periods, proper mulching, fungicide treatments using labeled chemicals, pruning of diseased host material, and liquid fertilization.

Although many trees appeared healthy, dogwood appears to have been functionally removed from the forested ecosystem at GNMP by a non-native exotic pathogen, similar to what has happened across Eastern North America over the past century with other species and disease; such as, American and slippery elm (Dutch elm disease), American chestnut (chestnut blight fungus) and redbay (Laurel wilt). Further losses of flowering dogwood may be expected at GNBP and without adequate regeneration, eventual extirpation of susceptible trees may be anticipated.

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